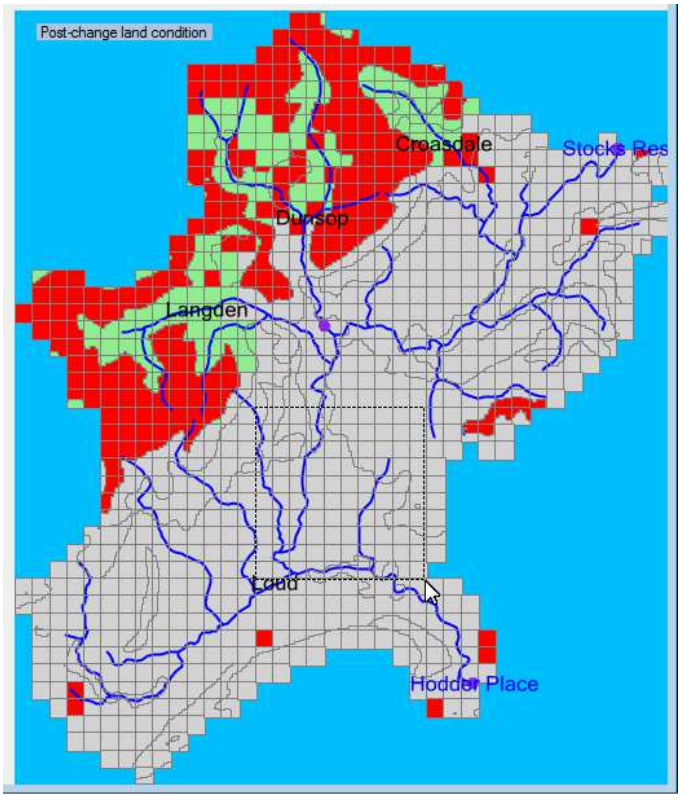
User Guide for Source-Pathway-Receptor Modelling Tool for Estimating Flood Impact of Upland Land Use and Management Change



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Statement of Use

This user guide and associated demonstration software tool is intended to be used by researchers and practitioners who are interested in a new method for quantifying and visualising impacts of land use management on flood flows and how these vary spatially over a catchment. The software demonstrates the approach for a particular case study and is not suitable in its current form for application to other case studies.

Obtaining the Software

The demonstration software tool and support can be obtained from Greg O'Donnell (Newcastle University): G.M.ODonnell@ncl.ac.uk

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1 Introduction

There is a fundamental need to understand the causal link between land management in rural river catchments and the rate of inflow to flood sites downstream. This understanding is needed when assessing the role played by land management practices in historical floods, and when land management interventions are proposed for flood risk management.

Numerical modelling is the only practical tool for studying the causal links in detail. This has known limitations: the landscape is a mosaic comprising small tiles with different land use, management practices, and soils, and there is no guaranteed or agreed way to create accurate models for the runoff from these tiles. A further difficulty is that accuracy is needed in simulating the sensitivity of the runoff to changes in land management, which is a poorly understood problem that has had little study. If these limitations are to be overcome, new methods for modelling will be needed.

In semi-distributed modelling, runoff from subcatchments or tiles can be routed through the channel drainage network to the catchment outlet or flood site. Some information on causal links can be established by analysing the sensitivity of routed flows to perturbations in the magnitude of the parameters that represent the effect of land use management on the runoff from the mosaic tiles.

This is the user guide for a tool that demonstrates an outcome from work on a new efficient and informative approach to analysing the impact of changes in land use management. This approach can be used with any distributed catchment rainfall-runoff model, provided the model can be differentiated using algorithmic differentiation (Griewank, 2000; Hascoët and Pascual, 2004) to obtain an adjoint model that gives estimates for the sensitivity of the peak discharge to the model's parameters. The tool uses results from a custom-designed adjoint semi-distributed rainfall-runoff model of the River Hodder catchment, northwest England, in which the rainfall-runoff-routing-flooding process is represented as a source-pathway-receptor system. The adjoint model was developed by John Ewen and Greg O'Donnell. It uses tile runoff models and parameter sets provided by Nataliya Bulygina and Caroline Ballard, Imperial College, London. Further information is provided in Ewen et al., 2012, which can be obtained from G.M.ODonnell@ncl.ac.uk. The tool was developed by John Ewen in C# using the DotSpatial open-source GIS (http://dotspatial.codeplex.com/).

1.1 What the tool does

Results obtained from the adjoint model have been integrated into the tool for three historical rainfall events. Using the mouse, the user can interactively adjust the land condition for each tile on the mosaic to the appropriate value (poor, fair or good), to represent a programme of change in land use management. The software then displays impact mosaic maps that show estimates for the impact these changes would have had on the peak flow rate for the three events. Uncertainty is accounted for in that three separate impact mosaic maps can be displayed. These show the impact

exceeded in 5, 50 and 95 of 100 sets of simulations run using the adjoint model in a simple Monte-Carlo approach.

2 Installation Prerequisites

Microsoft .NET Framework 4 must be installed on the computer, which can be downloaded from:

http://www.microsoft.com/download/en/details.aspx?id=17851

A PDF viewer is required to access the online help system.

3 Starting the Tool

1. Uncompress 'SPR_tool_Version2.zip'
2. Double click on directory 'SPR_tool_Version2'
3. Double click on 'run_SPR_tool_2.bat'

Firstly a command prompt window will open, and then after several seconds a window will appear as shown in **Fig. 1**.

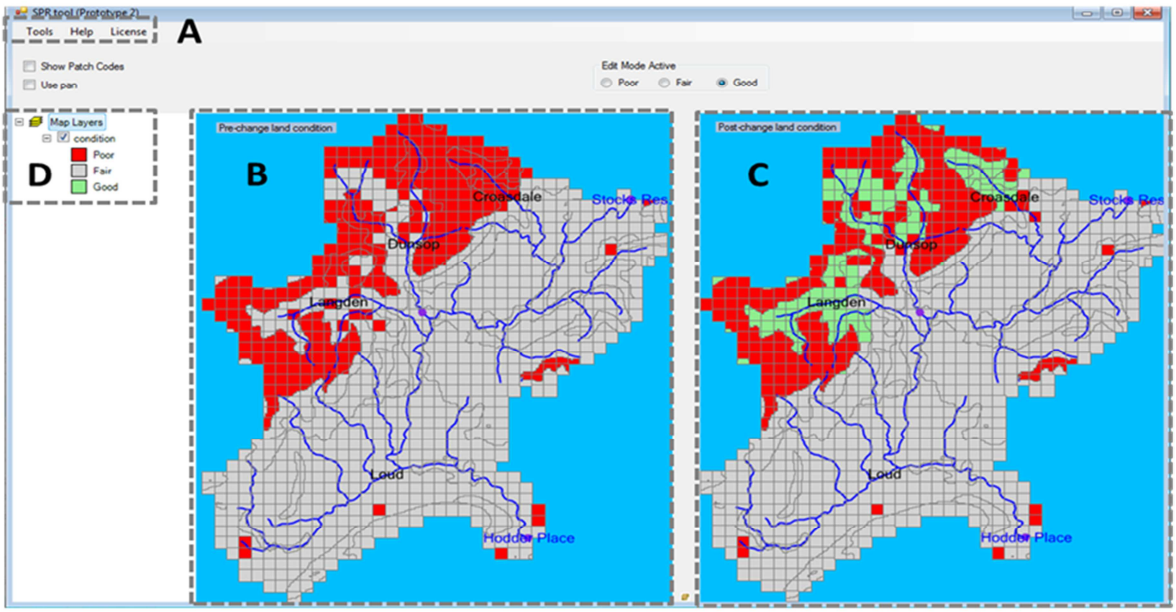

Figure 1: Tool overview

4 Help System

Documentation about the tool may be accessed through the 'Help' menu (**Fig. 1 Box A**). Clicking on a sub-menu item (**Fig. 2**) opens a PDF file that contains the relevant information. This Guide document can be accessed by clicking the 'Guide' sub-menu.

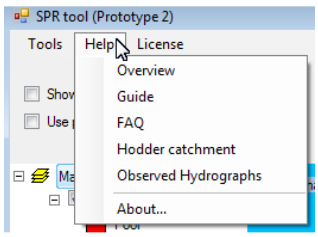

Figure 2: Help menu

5 Land Condition Maps

Pre-change and post-change maps of land condition are shown for the Hodder catchment in **Fig. 1** in **Boxes B and C**, respectively. **Box D** contains the key for the colour shading used to indicate land condition.

6 Impact Maps

To view the effect of the changes in land condition on the hydrograph peak at the catchment outfall at Hodder Place, select the 'Show Impact' sub-menu under the 'Tools' menu, **Fig. 3**.

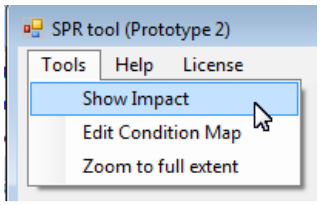

Figure 3: Tools menu

Impact maps are shown in **Fig. 4**. By default, the left-hand map (**Box E1**) is for the 5% exceedence (**E2**) and the right-hand map (**F1**) is for the 95% exceedence (**F2**). (The exceedence reflects uncertainty in prediction; 5%, 50% and 95% exceedence values can be selected, **Box E2** and **F2**.) Contributions to the hydrograph peak decrease in areas shaded yellow/green and increase in areas shaded red (**Box G**). The total impact on the hydrograph peak is shown for the maps in **Boxes E3** and **F3**. Impact maps can be generated for several historical storms (**Box H**). The observed hydrographs for these storm events are provided in the 'Help' system under the 'Observed Hydrograph' sub-menu.

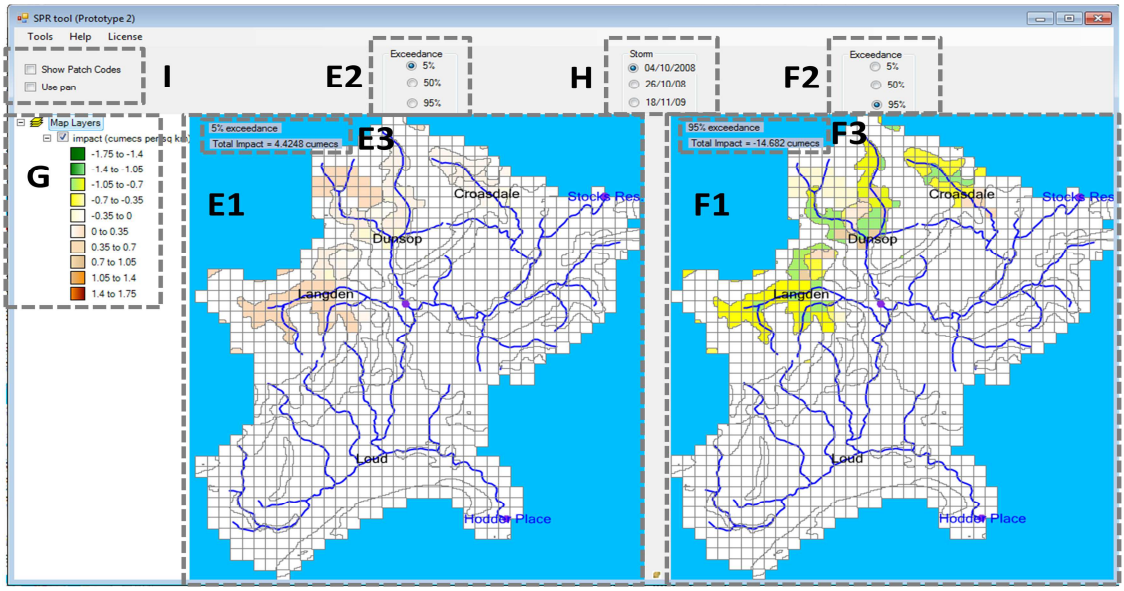

Figure 4: Impact Maps

7 Map Navigation

Several map navigation features are provided:

- To zoom in on a map, click the left mouse button; to zoom out use the right button
- To zoom to an area, press and hold the left mouse button, drag a rectangle and then release
- To pan across the map, select the 'Use pan' check box, **Fig 4 Box I**
- To reset the map extent, select the 'Zoom to Full extent' sub-menu under the 'Tools' menu (**Fig. 3**)

8 Editing Land Condition Maps

The user can interactively edit the land condition maps and view the revised Impact Maps.

- Under the 'Tools' menu select 'Zoom to full extent'
- If Impact Maps are displayed (as in **Fig 4**), select 'Show condition' from the 'Tools' menu (the display should be as in **Fig. 1**)
- Select 'Edit condition map' from the 'Tools' menu
- Above the maps a set of radio buttons will appear, labelled 'Edit Mode Active', **Fig. 5**.

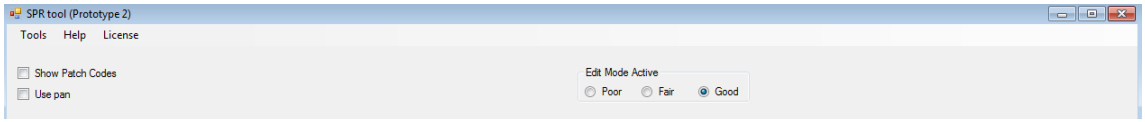

Figure 5: Edit mode controls

Maps **6a-6c** below show the right-hand side map (the post-change map) during three stages of an edit . To recreate these do the following:

- Click the 'Poor' radio button from the 'Edit Mode Active' menu
- Drag a rectangle over the right-hand side post-change map and release (**Fig. 6a**)
- The rectangle will be shaded red, indicating poor condition (**Fig. 6b**)
- As before, revised Impact maps can be viewed by selecting 'Show impact' from the 'Tools' menu (**Fig. 6c**).

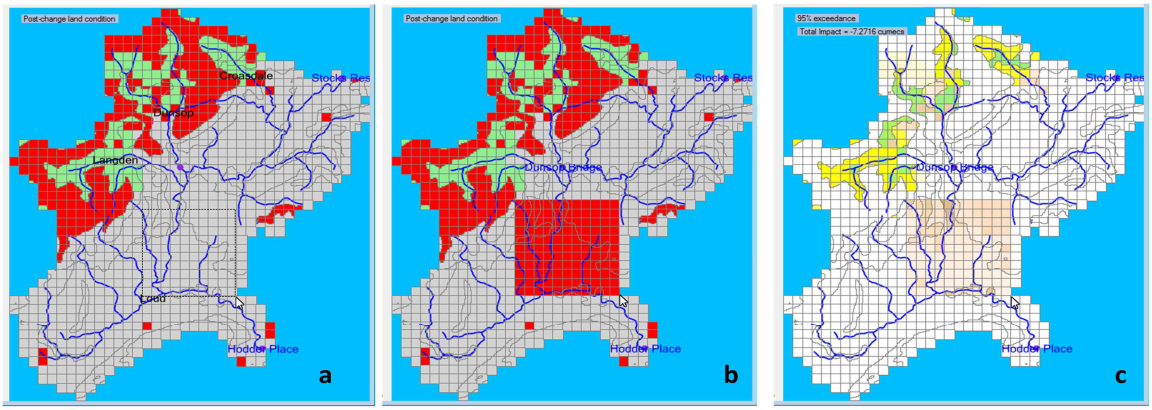

Figure 6 Editing post-condition map

- The maps comprise 500m grid cells. Each cell is broken into one or more 'patches', with each patch associated with a soil type and land use
- To view patch information, zoom to the portion of the map changed in Fig 6c
- Select 'Show Patch Codes' (**Fig. 4 Box I**)
- **(Enabling 'Show Patch Codes' slows the screen refresh rate.)**

The patch codes, **Fig. 7**, comprise a letter, indicating the land cover type and a number giving the soil (HOST) class. The land cover types included are:

A: agriculture
C: coniferous forest
D: deciduous forest
G: grassland
R: rough grazing
P: peat

For example, patch code G_24 indicates grassland with soil class 24 (a slowly permeable, seasonally waterlogged soil).

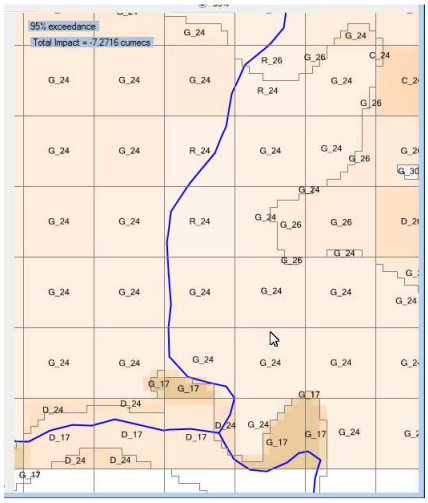

Figure 7: Patch codes

The land condition of individual patches can also be changed:

- Select 'Show condition' from the 'Tools' menu
- Choose a condition from the 'Edit Mode Active' radiobar menu
- Click on individual patch[es]

Once complete, the Impact maps can again be viewed by selecting 'Show impact' from the tools menu.

9 References

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